tactile information using electrical stimulation. The tactile information is then supplied to the wearer. The image information acquired by the camera is converted to tactile information through two processes. In a first process, spatial contour extraction is carried out in order to enhance the contour information. In a second process, temporal band-pass filtering is carried out in order to enhance time-varying information. FRS can therefore easily analyze images by simulating the pre-processing of an actual visualization system. Through an appropriate training program, the FRS can function as an artificial retina for the visually impaired without any surgery being required.

[B] Configuration of Forehead-Mounted Electrical Stimulation Presentation Board Suited to the Curvature of a Person's Forehead

[B-1] Problems with Forehead-Mounted Electrical Stimulation Presentation Board of the Related Art

[0040] The forehead-mounted electrical stimulation presentation board of the related art does not describe a specific method for arranging an electrode matrix on a person's forehead. However, if the electrode substrates are simply arranged on a person's forehead, there are the problems that: this is not appropriate for the curvature of a person's forehead; and that the amount of cabling required to extend to each of the electrodes when the number of electrodes is increased is problematic.

[0041] We therefore propose the followings. First, a stimulation electrode substrate shall be configured as follows. Electrical stimulation electrodes **5** are exposed at the surface of the substrate **4**A. A circuit element **6** including a switching circuit for selecting electrodes to be stimulated and a communication circuit is then mounted on the rear surface side of the substrate **4**A (FIG. **2**). The wiring on the substrate can be dramatically reduced by locating the electrodes and the switching circuit in close proximity. The number of wires between the forehead stimulation electrode substrate and a stimulation current generating circuit worn on another part of the body can then be kept at a fixed amount or less by carrying out communication of instruction signals to the switching circuit (this is typically wired serial communication or wireless communication).

[B-2] Configuration for Forehead-Mounted Electrical Stimulation Presentation Board Employing a Flexible Substrate and Conductive Gel

[0042] A flexible substrate **4** is adopted as the substrate so that the substrate is lightweight and suited to the shape of a person's forehead (FIG. **3**). Polyimide film that is currently most typically used can be considered as a material for the flexible substrate but it is also possible to use an elastic film employing a material having elasticity such as silicon rubber, or a type of film that employs a thermoplastic resin and can be molded through the application of heat after wiring the substrate. In particular, the curvature of a person's forehead can be determined to a certain extent. A material that can be molded along the curvature is therefore preferable and a thermoplastic resin is the candidate. Electrode pins **5** are formed on land (exposed portions for soldering use) of the flexible substrate **4** using gold plating processing **5**A.

[0043] A conductive gel layer **7** is provided on the electrode pins **5** formed on the flexible substrate **4**. Hydrogel (where water and an electrolyte are suspended in hydrophilic resin) that is currently commonly used in electrical stimulation as a conductive gel can be considered. This conductive gel layer is not just for maintaining electrical contact between the electrodes and the skin, but is also for preventing focusing of current within the skin and preventing pain caused by the current.

[0044] The following is a description of a function of the conductive gel layer. First, pain sense nerves that generate a sense of pain, and tactile nerves that generate senses of vibration and pressure exist under the skin. The thickness of a nerve axon is in the order of one micrometer to five micrometers, respectively. With electrical stimulation from the skin, a potential difference between membranes fluctuates as a result of a potential distribution surrounding nerve axons to causes nerve activity. It is known that if the distance from the skin surface to the nerve axons is fixed, a current threshold value that causes nerve activity is inversely proportional to the thickness of the nerve axons or inversely proportional to the square root of the thickness. This means that the tactile nerves are easier to stimulate than the pain sense nerves, and that it is possible to achieve tactile sensation without pain occurring. However, in reality the distance from the surface of the skin to the nerve axons is not fixed and the electrical resistance distribution of the skin is also not fixed. This means that situations occur where the current becomes localized so that pain sense nerves are stimulated. In order to diminish this problem, electrically conductive gel is interposed between the electrodes and the skin. Focusing of the current can then be prevented as a result of the current being diffused by the gel layer.

[0045] The following four relationships exist between the four items of the thickness of the conductive gel, the distance between an anode and a cathode, gel impedance, and impedance of the skin (refer to FIG. **2**A).

(1) When the gel impedance is relatively low compared to the skin impedance, a current path is formed within the gel layer and reaching the skin is difficult. This means that the majority of consumed power is taken up in the generation of Joule heat at the gel layer and is an extremely critical problem for a portable tactile presentation device.

(2) When the thickness of the gel is large compared to the gap between the electrodes, a current path is similarly formed within the gel layer and it is difficult to reach the skin.

(3) When the gel is thin, it becomes easy for pain to occur because the effect of diffusing the current is reduced.

(4) When the impedance of the gel is large, the majority of the consumed power is consumed in the generation of joule heat at the gel layer.

[0046] With the transcutaneous electrical stimulation of the related art, forming a current path within the gel layer was not a big problem because there was sufficient distance between the anodes and cathodes (an electrode gap of 5 millimeter or more). A conductive gel of a low resistance (10 to 50 KΩcm, typically 20 KΩcm) was used in order to deal with the above problem (3). However, when a large number of electrodes are arranged densely as on the present occasion (an electrode gap of 1 millimeter to 5 millimeter), an optimum resistance setting is newly required so as to keep the forming of a current path within the conductive gel layer to a minimum and to prevent occurring of pain by diffusing of the current.

[0047] In order to achieve this role, we found that when the conductive gel has a thickness of 0.3 millimeters to 2.0 millimeters with an optimum thickness of approximately 0.5 millimeters to 1.0 millimeter, and the resistance value of the gel is a high resistance value (100 to 1000 KΩcm, and typi-